Chapter 5

Chemical Reactions

Chemical Reaction

- Another name for a chemical change
- New properties when you are done
- No new atoms are made
- Atoms are rearranged
- New compounds can be made
- Old bonds are broken
- New bonds are formed

Indications of Chemical Reactions

- New properties
- Color change
- Odor change
- New phase is made
  - Precipitates- solids in a liquid
  - Gases- bubbles in a liquid
- Two parts of reaction
  - Reactants- the stuff you start with
  - Products- the stuff you make

Starting a Reaction

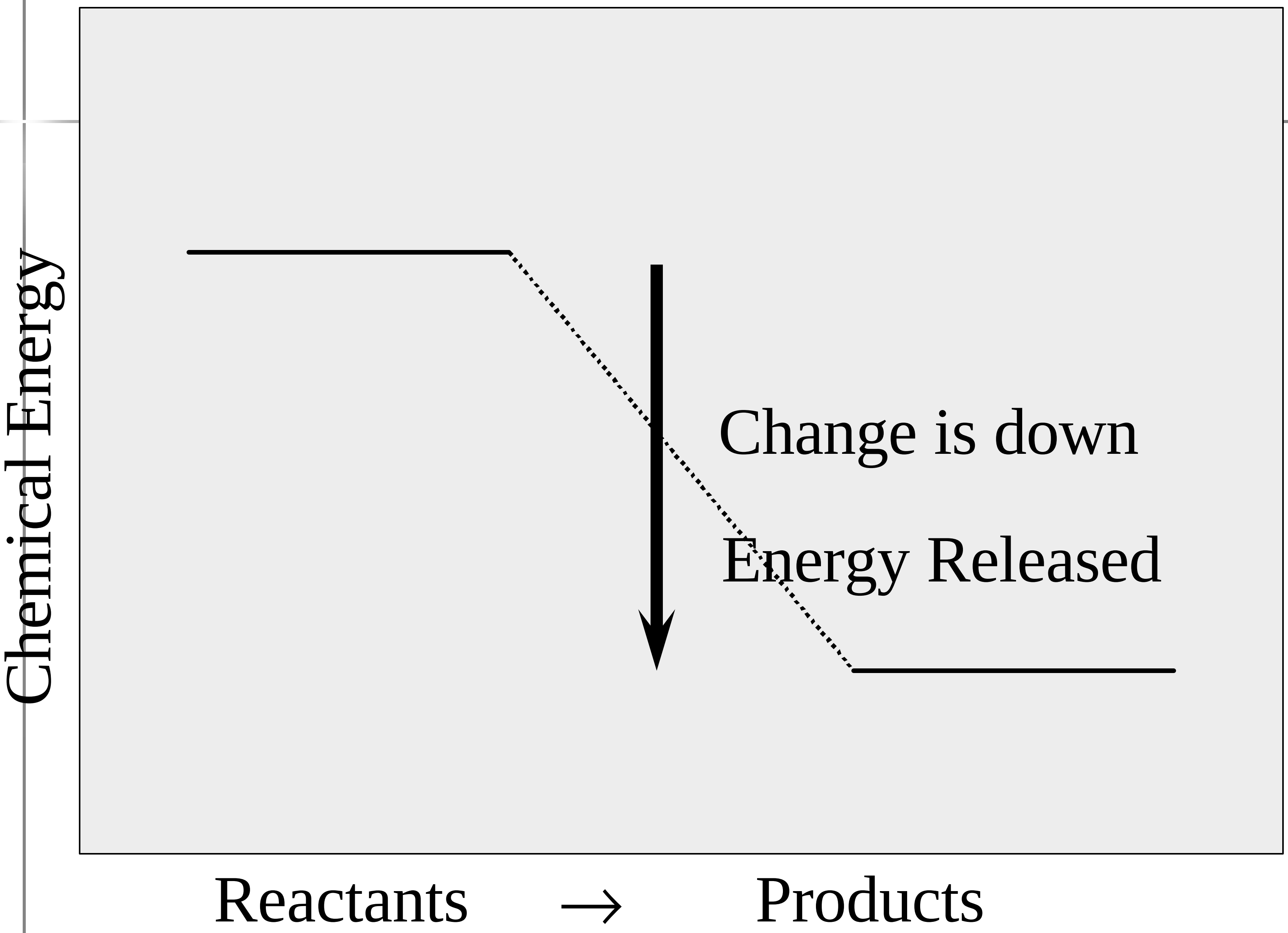
- Always takes a little energy
- Energy goes into breaking bonds in the reactants
- Can use different forms of energy
- Heat
- Electricity
- Light

Forming Bonds Makes Energy

- Releases energy
- Energy is conserved
- Chemical Energy- energy stored in the bonds of the chemicals.
- Reactions have an energy change

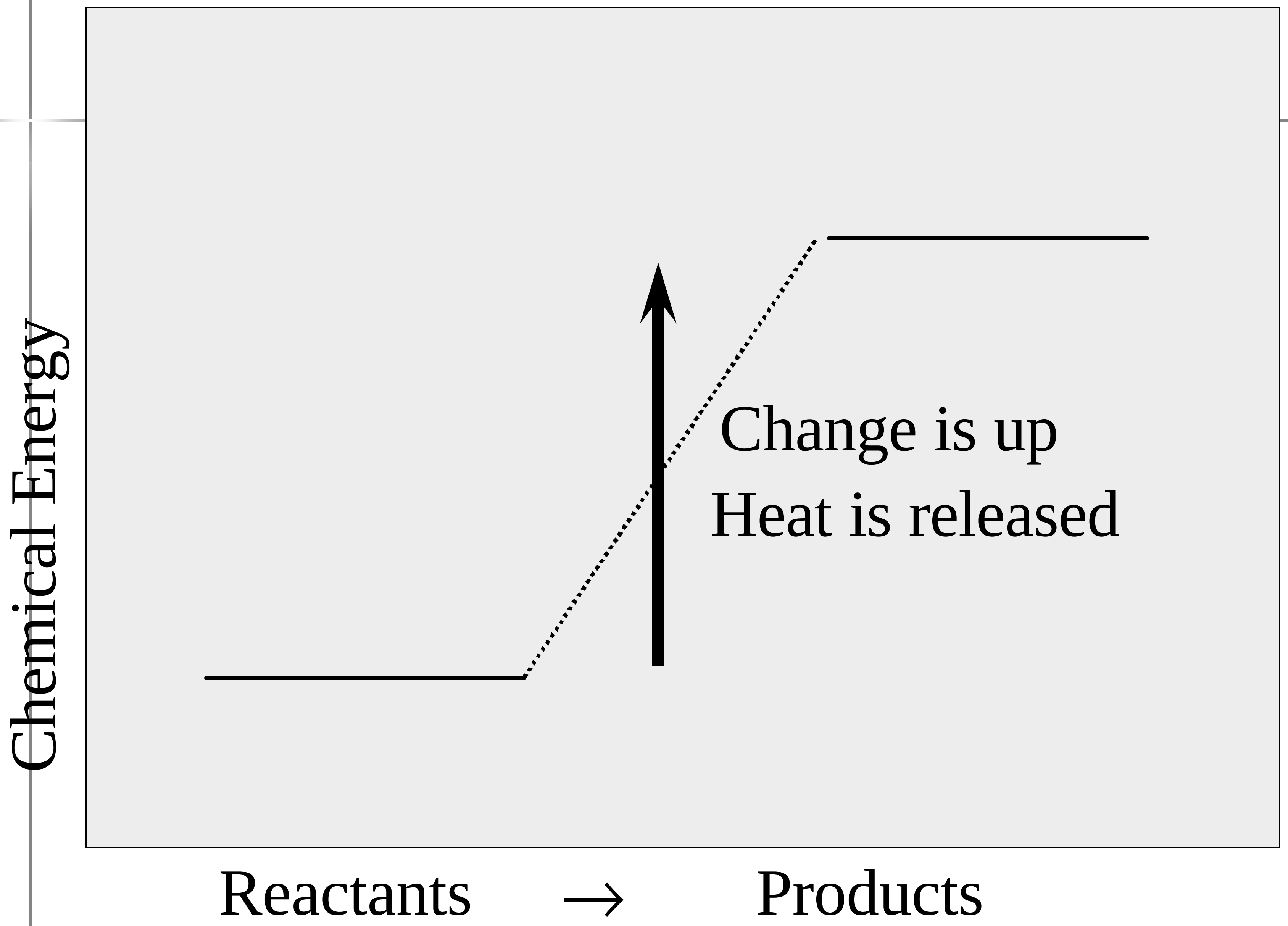
Exothermic Reactions

- If breaking bonds takes less energy than making them- it releases energy
- *Exo*- outside
- *therm*- heat
- Exothermic reactions release energy
- Get hot
- Give off light
- Or release electricity


Chemical Energy
Change is down
Energy Released
Reactants → Products

Endothermic Reactions

- If breaking bonds takes more energy than making them- it absorbs energy
- *Endo*- inside
- *therm*- heat
- Endothermic reactions absorb energy
- Get cold
- Require heat or energy or they stop

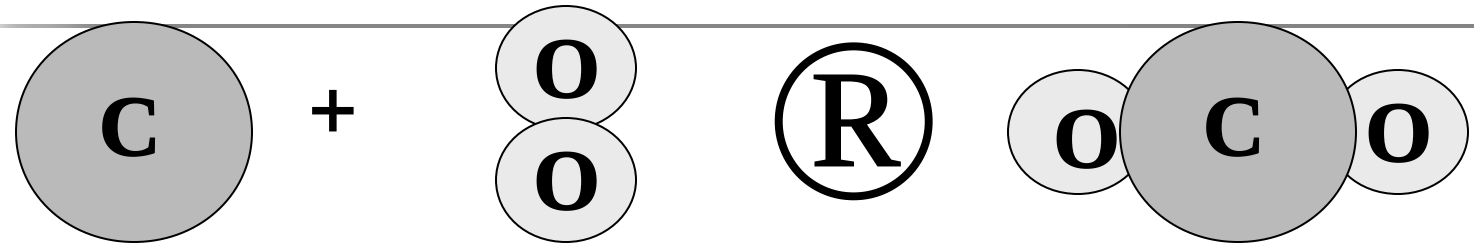

Chemical Energy
Change is up
Heat is released
Reactants → Products

Chemical Equations

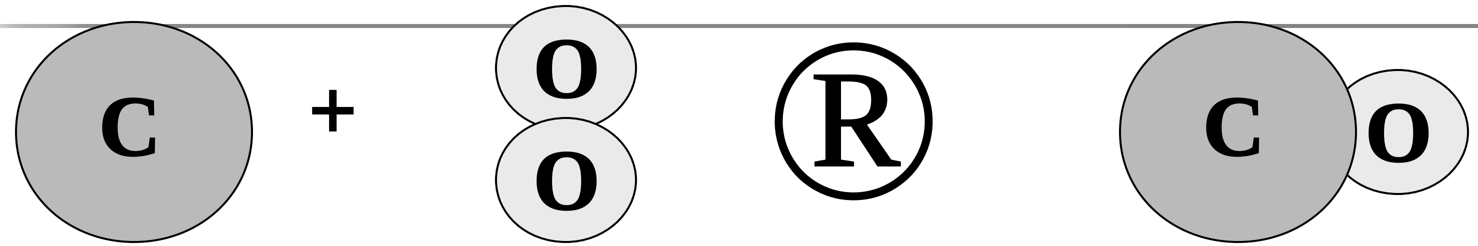
- Copper reacts with chlorine to form copper (II) chloride.
- In a word equation
- Methane + oxygen $\rightarrow$ water +carbon dioxide
- Arrow means “yields” or “makes”
- The plus sign means “and”
- Can use formulas
- $CH_4 + O_2 \rightarrow CO_2 + H_2O$

Balanced Equation

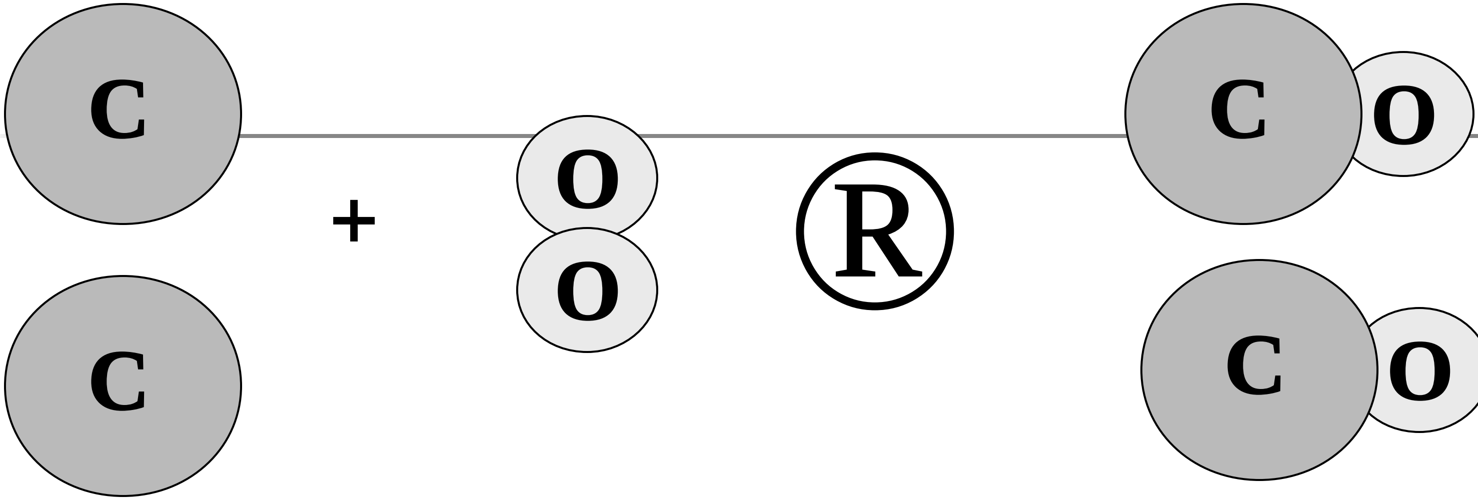
- Atoms can’t be created or destroyed
- All the atoms we start with we must end up with
- A balanced equation has the same number of each element on both sides of the equation.



- $C + O_2 \rightarrow CO_2$
- This equation is already balanced
- What if it isn't already?



- $C + O_2 \rightarrow CO$
- We need one more oxygen in the products.
- Can’t change the formula, because it describes what is



- Must have started with two C
- $2\ C + O_2 \rightarrow 2\ CO$

Rules for balancing

1. Write the correct formulas for all the reactants and products
2. Count the number of atoms of each type appearing on both sides
3. Balance the elements one at a time by adding coefficients (the numbers in front)
4. Check to make sure it is balanced.

Never

- Change a subscript to balance an equation.
- If you change the formula you are describing a different reaction.
- H_2O is a different compound than H_2O_2
- Never put a coefficient in the middle of a formula
- 2 NaCl is okay, Na2Cl is not.

Example

$H_2 + O_2$ ® H_2O

Make a table to keep track of where you are at

Example

$H_2 + O_2$ ® H_2O

R		P
2	H	2
2	O	1

Need twice as much O in the product

Example

$H_2 + O_2$ ® $2\,H_2O$

R		P
2	H	2
2	O	1

Changes the O

Example

$H_2 + O_2$ ® $2\ H_2O$

R		P
2	H	2
2	O	~~1~~ 2

Also changes the H

Example

$H_2 + O_2$ ® $2\ H_2O$

R		P	
2	H	~~2~~	4
2	O	~~1~~	2

Need twice as much H in the reactant

Example

$$2\ H_2 + O_2 \ ® \ 2\ H_2O$$

R		P	
2	H	~~2~~	4
2	O	~~1~~	2

Recount

Example

$2\,H_2 + O_2$ ® $2\,H_2O$

R			P	
4	~~2~~	H	~~2~~	4
	2	O	~~1~~	2

The equation is balanced, has the same number of each kind of atom on both sides

Example

$$2\,H_2 + O_2 \text{ ® } 2\,H_2O$$

	R		P	
4	~~2~~	H	~~2~~	4
	2	O	~~1~~	2

This is the answer

Not this

Examples

- $AgNO_3 + Cu \rightarrow Cu(NO_3)_2 + Ag$
- $Mg + N_2 \rightarrow Mg_3N_2$
- $P + O_2 \rightarrow P_4O_{10}$
- $Na + H_2O \rightarrow H_2 + NaOH$
- $CH_4 + O_2 \rightarrow CO_2 + H_2O$

Examples of Balancing Equations

a) $Pb(NO_3)_2 + K_2CrO_4 \rightarrow PbCrO_4 + KNO_3$

b) $MnO_2 + HCl \rightarrow MnCl_2 + H_2O + Cl_2$

c) $C_3H_6 + O_2 \rightarrow CO_2 + H_2O$

d) $Zn(OH)_2 + H_3PO_4 \rightarrow Zn_3(PO_4)_2$

e) $CO + Fe_2O_3 \rightarrow Fe + CO_2$

f) $CS_2 + Cl_2 \rightarrow CCl_4 + S_2Cl_2$

g) $CH_4 + Br_2 \rightarrow CH_3Br + HBr$

h) $Ba(CN)_2 + H_2SO_4 \rightarrow BaSO_4 + HCN$

Moles and Reactions

- $2H_2 + O_2 \rightarrow 2H_2O$
- 2 dozen molecules of hydrogen and 1 dozen molecules of oxygen form 2 dozen molecules of water.
- 2 x (6.02 x 10^{23}) molecules of hydrogen and 1 x (6.02 x 10^{23}) molecules of oxygen form 2 x (6.02 x 10^{23}) molecules of water.
- 2 moles of hydrogen and 1 mole of oxygen form 2 moles of water.

Moles and Reactions

- The coefficients of balanced equations tell how many particles react
- And how many moles of particles
- We can make ratios with those moles
- $2\ Mg + O_2 \rightarrow 2\ MgO$
- If 2 moles of Mg react, 1 mole of O_2 will be required
- $\frac{2 \text{ mol Mg}}{1 \text{ mol } O_2}$ or $\frac{1 \text{ mol } O_2}{2 \text{ mol Mg}}$

Mole ratios

- Can be used to figure out how many moles of products and reactants were used or made
- $2H_2 + O_2 \rightarrow 2H_2O$
- If 6 mole of H_2 react, how many moles of water will form?
- How many moles of hydrogen are needed to react with 3.6 mole of oxygen?

Mole to mole conversions

- $2\ Al_2O_3 \rightarrow 4Al + 3O_2$
- every time we use 2 moles of Al_2O_3 we make 3 moles of O_2

$$\left(\frac{2\text{ moles }Al_2O_3}{3\text{ mole }O_2}\right) \quad \text{or} \quad \left(\frac{3\text{ mole }O_2}{2\text{ moles }Al_2O_3}\right)$$

Mole to Mole conversions

- How many moles of O_2 are produced when 3.34 moles of Al_2O_3 decompose?
- $2\ Al_2O_3 \rightarrow 4Al + 3O_2$

$$3.34 \text{ moles } Al_2O_3 \left(\frac{3 \text{ mole } O_2}{2 \text{ moles } Al_2O_3}\right) = 5.01 \text{ moles } O_2$$

Your Turn

- $2C_2H_2 + 5\ O_2 \rightarrow 4CO_2 + 2\ H_2O$
- If 3.84 moles of C_2H_2 are burned, how many moles of O_2 are needed?
- How many moles of C_2H_2 are needed to produce 8.95 mole of H_2O?
- If 2.47 moles of C_2H_2 are burned, how many moles of CO_2 are formed?

Collision Theory

- In order to react molecules and atoms must touch each other.
- They must hit each other hard enough to react.
- Anything that increase these things will make the reaction faster.

Things that Affect Rate

- Temperature
- Higher temperature faster particles.
- More and harder collisions.
- Faster Reactions.
- Concentration
- More concentrated closer together the molecules.
- Collide more often.
- Faster reaction.

Things that Affect Rate

- Particle size
- Molecules can only collide at the surface.
- Smaller particles bigger surface area.
- Smaller particles faster reaction.
- Smallest possible is molecules or ions.
- Dissolving speeds up reactions.
- Getting two solids to react with each other is slow.

Things that Affect Rate

- Catalysts- substances that speed up a reaction without being used up.
- Inhibitor- a substance that blocks a catalyst, slowing the reaction down
- Enzymes are biological catalysts- made by plants and animals to control reactions
- Heat destroys most catalysts

Reactions

- Some go to completion
- All the reactants get turned into products
- No reactants left
- Some reactions go both directions
- They are called reversible reactions

Reversible Reactions

- $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ + energy
- $2H_2O(g)$ + energy $\rightarrow 2H_2(g) + O_2(g)$
- $2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(g)$ + energy

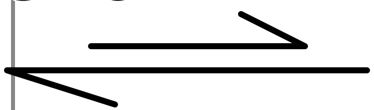
Equilibrium

- When I first put reactants together the forward reaction starts.
- Since there are no products there is no reverse reaction.
- As the forward reaction proceeds the reactants are used up so the forward reaction slows.
- The products build up, and the reverse reaction speeds up.

Equilibrium

- Eventually you reach a point where the reverse reaction is going as fast as the forward reaction.
- This is dynamic equilibrium.
- The rate of the forward reaction is equal to the rate of the reverse reaction.
- The concentration of products and reactants stays the same, but the reactions are still running.

Equilibrium

- Equilibrium position- how much product and reactant there are at equilibrium.
- Shown with the double arrow.
-  Reactants are favored
-  Products are favored
- Catalysts speed up both the forward and reverse reactions so don’t affect equilibrium position.

LeChâtelier's Principle

Regaining Equilibrium

LeChâtelier's Principle

- If something is changed in a system at equilibrium, the system will respond to undo that change.
- Three types of changes are described.

Changing Concentration

- If you add reactants (or increase their concentration).
- The forward reaction will speed up.
- More product will form.
- Equilibrium "*Shifts to the right*"
- Reactants $\rightarrow$ products

Changing Concentration

- If you add products (or increase their concentration).
- The reverse reaction will speed up.
- More reactant will form.
- Equilibrium "*Shifts to the left*"
- Reactants ← products

Changing Concentration

- If you remove products (or decrease their concentration).
- The reverse reaction will slow down
- More product will form.
- Equilibrium reverse“*Shifts to the right*”
- Reactants $\rightarrow$ products

Changing Concentration

- If you remove reactants (or decrease their concentration).
- The forward reaction will slow down.
- More reactant will form.
- Equilibrium "*Shifts to the left*".
- Reactants $\leftarrow$ products
- Used to control how much yield you get from a chemical reaction.

Changing Temperature

- Reactions either require or release heat.
- Endothermic reactions go faster at higher temperature.
- Exothermic go faster at lower temperatures.
- All reversible reactions will be exothermic one way and endothermic the other.

Changing Temperature

- As you raise the temperature the reaction proceeds in the endothermic direction.
- As you lower the temperature the reaction proceeds in the exothermic direction.
- Reactants + heat $\rightarrow$ Products at high T
- Reactants + heat $\leftarrow$ Products at low T

Changes in Pressure

- As the pressure increases the reaction will shift in the direction of the least gases.
- At high pressure

$$2H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$$

- At low pressure

$$2H_2(g) + O_2(g) \leftarrow 2\ H_2O(g)$$